TWO FOSSIL INSECTS FROM FLORISSANT, COLORADO, WITH A DISCUSSION OF THE VENATION OF THE AESHNINE DRAGON-FLIES.

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The Florissant shales continue to yield important new materials for the study of Tertiary insect life. The specimens now discussed are of special interest because of their relation to certain modern forms, and in one case the investigation has been extended to include the venational characters of the allied modern genera.

Order ODONATA.

Family AESHNIDÆ.

OPLONÆSCHNA LAPIDARIA Cockerell and Counts, new species.[1]

Hind wing of male; length about 42 mm.; hyaline, venation piceous; stigma dark piceous; stigma 5 mm. long, bounding 3½ long cells below; triangle of five cells, two basal, the formula 2, 1, 1, 1; branches of media leaving arculus considerably below middle; M_3 and M_4 at margin of wing separated by two cells, M_4 and the supplement also separated by two (one only in *O. armata*); M_4 without any evident deflection or bulging about six cells from margin (such a bulging very distinct in *O. armata*); Rs unbranched, separated from the supplement below it by about five rows of cells at widest part (three or four in *O. armata*).

Compared with the living *O. armata*, the stigma is much longer, and in the type-specimen has a cross vein (Mr. E. B. Williamson thinks this is a freak, but that such freaks are probably confined to species with a long stigma. Needham's figure of *Tachopteryx*, which has an excessively long stigma, appears to show a cross vein); the cell beyond the stigma is not nearly twice as long as the next following one; the origin of the branches of the media from the arculus is

[1] This species was first studied and drawn by Miss Hilda Counts, whose work has been incorporated in this paper.

quite different. Compared with the Florissant fossil *O. separata* (Scudder), *O. lapidaria* is at once separated by the low origin of the branches of the media from the arculus, which is certainly not due to distortion. From the level of the arculus to the lower corner of the triangle there are three full cells, whereas *O. separata* and *O. armata* show only 2 to $2\frac{1}{2}$. The ends of M_3 and M_4 and the supplement agree remarkably well with the European fossil *O. metis* (Heer), but *metis* has the branches of the media arising from even a little above the middle of the arculus. The radial sector and its supplement, with the cells between, are more like those of *O. metis* than those of the living *O. armata*.

Locality.—Miocene shales of Florissant, Colorado, Station 13 B, University of Colorado Expedition; collected by S. A. Rohwer.

Cotypes.—Cat. No. 59922, U.S.N.M.

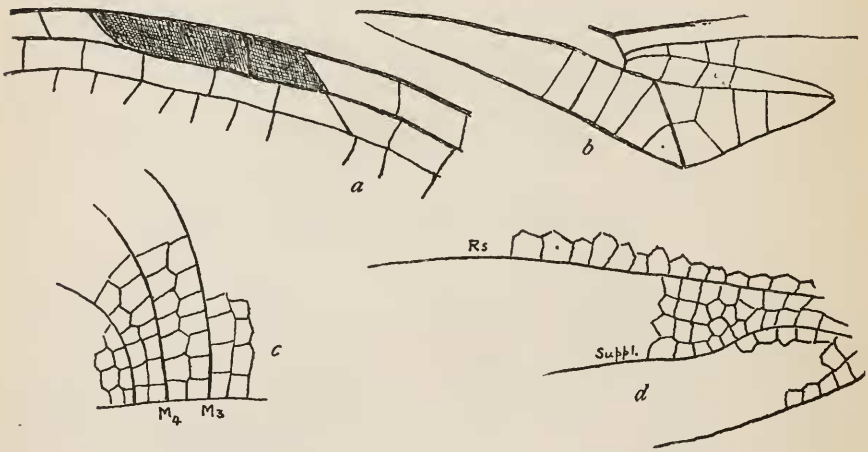

FIG. 1.—OPLONÆSCHNA LAPIDARIA. *a*, STIGMA; *b*, TRIANGLE AND ARCULUS; *c*, ENDS OF VEINS M_3 AND M_4; *d*, RADIAL SECTOR AND SUPPLEMENT.

This specimen puzzled us much, on account of the peculiar origin of the branches of the media from the arculus, a condition not found in the allied species or genera. There are genera, as *Planæschna* (fig. 2, *b*, *c*), in which the origin is below the middle, but these are otherwise quite different; as this character shows no evidence of being abnormal in any way, we can only regard the wing as representing a new species.

I consulted Mr. E. B. Williamson on some of the characters of this species, and he was so kind as to loan me a very fine series of photographs of various Aeshnine genera. Using these with other materials already in my possession, I have made a key to the principal genera of Aeshninæ, based on the venation. This is given below, and it is hoped that it will be of service in determining fossils, which are usually represented only by the wings. An effort has been made

to cite truly generic characters as far as possible, but the specific names are usually given, to show what species were used in the study. In some cases other species were available, but were not included, as they introduced no important additional characters.

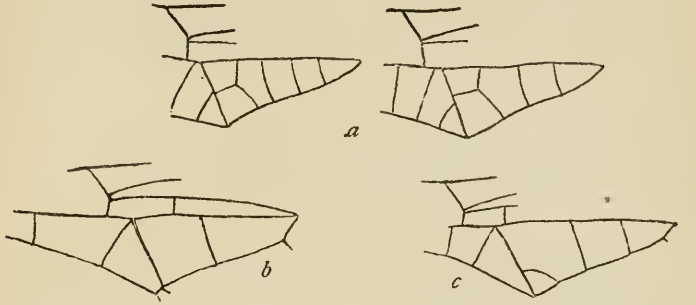

FIG. 2.—*a*, OPLONÆSCHNA SEPARATA (SCUDDER), TRIANGLES FROM TWO SPECIMENS COLLECTED AT STATION 14, FLORISSANT; *b*, PLANÆSCHNA MULTIPUNCTATA, TRIANGLE OF HIND WING; *c*, PLANÆSCHNA FORCIPATA, TRIANGLE OF HIND WING.

It is generally recognized that *Oplonaeschna* is a relatively primitive member of the Aeshninæ; it is therefore interesting to find it in the Tertiary rocks of both America and Europe. Nevertheless true *Aeshna*, of the modern type, was present in the Miocene of Florissant.

KEY TO THE PRINCIPAL GENERA OF AESHNINÆ, BASED ON THE VENATION.

(A) *Basal space without cross veins.*

(*a*) *Radial sector not branched; branches of media leaving arculus at or near middle* [below middle in *Oplonaeschna lapidaria*].

Radial sector separated from supplementary vein below it by one row of cells..... 1

Radial sector separated from supplementary vein below it by two rows of cells; triangle of anterior wings much longer and more slender than that of hind (the latter only three-celled).....*Allopetalia reticulata* [Williamson photo.].

Radial sector separated from supplementary vein below it by three rows of cells for a considerable distance; triangles of anterior and posterior wings more alike.. 3

Radial sector separated from supplementary vein below it by four rows of cells.....*Oplonaeschna metis* (Heer).[1]

1. Anal loop of hind wings of three cells; triangle of three cells; [abdomen modified].....*Oligoaeschna* [*Dolaeschna* Needham].

Anal loop of hind wings of more than three cells..... 2

2. Stigma bounding 1½ cells below; anal loop of 4 cells; triangle of 2 cells. *Gomphaeschna furcillata.*

Stigma bounding 2½ cells below; anal loop of 5 cells. (Miocene genus). *Lithaeschna.*[2]

3. Stigma narrow and elongate, bounding about 4½ cells below; triangle of anterior wings with three cells.....*Basiaeschna janata.*

Stigma much shorter and deeper, bounding about 2½ cells below; triangle of anterior wings with six cells.....*Oplonaeschna armata.*

[1] This is *Aeschna metis* Heer, fossil at Radoboj. Handlirsch, following Hagen, refers it to *Anax*, but Heer's figure shows that this can not be correct. The reference to *Oplonaeschna* has already been indicated by Needham. I reached the same conclusion before noticing Needham's remarks.

[2] The characters of *Lithaeschna* are set forth at length, and contrasted with those of *Gomphaeschna*, etc., in Bull. Amer. Mus. Nat. Hist., vol. 23, (1907) pp. 133-136. The triangle of *Lithaeschna* is three-celled by the division of the basal cell, as in *Allopetalia*. The genus is perhaps too close to *Gomphaeschna*.

(*b*) *Radial sector without a distinct branch, but with many slender branch-like veins arising from its lower side; branches of media leaving arculus near the top; supplementary vein below M_4 in hind wings with an extremely strong, almost S-like curve.* (Tribe Anacini, new.)

Triangle of hind wings four-celled, the basal cell not double; Cu_2 bent so that the part below the triangle is nearer the wing-margin than that just beyond.
Hemianax ephippigera [Williamson photo.].

Triangle of hind wings six-celled, with two basal; Cu_2 not bent as in *Hemianax*.
Anax junius.

(*c*) *Radial sector branched (forked).*

Radial sector separated from supplementary vein below it by only one row of cells; triangles with not more than three or four cells..... 1

Radial sector separated from supplementary vein below it by more than one row of cells..... 4

1. Stigma long, bounding about 3½ cells below..... 2
   Stigma short, bounding 2–2½ cells below; branches of Cu below triangle in hind wing separated by only one row of cells; branches of media leaving arculus considerably below its middle..... 3
2. Branches of Cu below triangle in hind wing separated by only one row of cells (but three rows near margin of wing); triangles of two cells..*Brachytron pratense*.
   Branches of Cu below triangle in hind wing separated in part by two rows of cells; triangles with three or four cells.....*Nasiaeschna pentacantha*.
3. Triangles normally with three cells (sometimes a small fourth cell)..*Planæschna forcipata* [photo. of this Queensland species sent by R. Martin to Williamson].
   Triangles with only two cells.....*Planæschna multipunctata* [Williamson photo.].
4. Triangles with eight cells; Rs separated from supplementary vein below it by many rows of cells (6 or 7 in widest part); branches of Cu below triangle in hind wing separated by two rows of cells; arculus far basad of triangle; wings more elongated than in *Gynacantha*..*Staurophlebia reticulata* [Williamson photo.].
   Triangles with three to six cells..... 5
5. Not more than two rows of cells between M_4 and supplementary vein below it in hind wing; triangles with five cells, the apical one very long; Rs separated from supplementary vein below it by more than one row of cells (3 in widest part); branches of Cu below triangle in hind wing separated in one place by two rows of cells; arculus of anterior wing not more remote from triangle than the equivalent of half length of base of latter.....*Aeschnophlebia anisoptera*.
   More than two rows of cells between M_4 and supplementary vein below it in hind wing..... 6
6. Fork of radial sector below middle of stigma (or a little before middle); triangles of four cells, only one basal; Rs separated from supplementary vein below it by 4 or 5 cells at widest part.....*Coryphæschna ingens*.
   Fork of radial sector before level of middle of stigma, nearly always before level of beginning of stigma..... 7
7. Triangles in both wings three celled, with only one basal cell; stigma longer and narrower than in *Ae. cyanea*..... 8
   Triangles with two basal cells, or rarely only one in anterior wing..... 9
8. Fork of radial sector considerably before level of stigma; branches of Cu below triangle in hind wings separated by two rows of cells.
   Aeshna bonariensis [Williamson photo.] female.
   Fork of radial sector below beginning of stigma; branches of Cu below triangle separated by one row of cells (except one double cell).
   Aeshna sp. from Brazil [Williamson photo.].
9. Triangles, at least in anterior wings, of six cells, a basal pair, and four simple ones beyond..... 10

Triangles with not more than five cells, or when rarely with six, two pairs, the formula 2, 2, 1, 1..... 11

10. Anal loop of seven cells.....*Gynacantha trifida.*
Anal loop of twelve cells.....*Gynacantha* from Siam [Williamson photo.].

11. M_3 and M_4 separated by one cell only at margin of wing, but a short distance before by two rows of cells, owing to the deflection of M_4 from the straight course; cell formula of triangles 2, 1, 1; upper branch of radial sector in a line with stem; Rs separated from supplementary vein below it by only three rows of cells; fork of Rs a short distance before level of beginning of stigma (subgenus HESPERAESHNA, new subgenus).....*Aeshna californica.*
M_3 and M_4 separated by at least two cells at margin of wing, so that they are almost or quite as far apart here as at any part of their course; triangles with five cells, at least in anterior wings; Rs separated from supplementary vein below it by four rows of cells, at least at widest part (mainly three rows, with four only at one place, in *Ae. solida*)..... 12

12. Anal loop in hind wings very large, with about 15 cells; stigma comparatively short.....*Aeshna cyanea* [Williamson photo.].
Anal loop in hind wings not so large..... 13

13. Branches of Cu below triangle separated by a single row of cells for the most part, but a few paired cells present, the number variable; upper branch of radial sector making a strong angle with the stem, but the lower branch nearly in a straight line with the stem.....*Aeshna solida* [fossil at Florissant].
Branches of Cu below triangle separated through most of their course by two rows of cells.....*Aeshna eremita.*

NOTE ON AESHNA.—I am unable to find any satisfactory generic characters in the venation to separate *Aeshna* from *Gynacantha*. According to E. M. Walker's phylogenetic tree, *Gynacantha* is derived from *Aeshna*. The number of cells in the triangle in *Aeshna* varies within specific limits, as was fully shown in American Journal of Science, vol. 26, 1908, p. 74. Walker, in his revision of North American *Aeshna*, finds the following venational characters valid for groups:

Anal triangle of males three-celled..... 1
Anal triangle of males two-celled; females with fork of Rs decidedly asymmetrical at base.....*Cærulea, juncea* and *clepsydra* groups.

1. Females with fork of Rs nearly symmetrical at base.
Californica and *multicolor* groups.
Females with fork of Rs decidedly asymmetrical at base.....*Cyanea* group.

For a further discussion of *Aeshna* venation see Entomological News, Dec., 1908, pp. 455–459.[1]

(B) *Basal space with cross veins.*

(*a*) *Radial sector not branched; branches of media leaving arculus at or near middle.*
Radial sector separated from supplementary vein below it by two rows of cells; stigma bounding more than three cells below; triangle of anterior wings with three cells.....*Boyeria irene.*

(*b*) *Radial sector branched.*

[1] An elaborate table, contrasting the venation of *Aeshna, Coryphæschna, Epiæschna, Planæschna,* and *Nasiæschna,* is given by Williamson in Entomological News, 1903, pp. 5–7. *Epiæschna* has a curiously intermediate, or as it were undecided, venation. Run in the table above, it goes to the vicinity of *Hesperæshna,* but with difficulty, because (1) Rs is separated from supplementary vein below it by a *partially* double row of cells; triangles have five cells; (2) M_4 is separated from supplementary vein below it in hind wing by only about three triple cells, the rest being double; (3) the triangle of *hind* wing has a simple basal cell in Williamson's figure; (4) M_3 and M_4 are separated by one cell at margin of wing, but although there is some doubling higher up in hind wing, M_4 is not deflected out of its course. Williamson states that the basal cell of triangle in *Epiæschna* is divided in front wing, and rarely divided in hind wing. He also states that the basal cell of the triangle is very rarely divided in *Coryphæschna.*

Triangles with 8 or 10 cells; M_2 strongly arched above fork of Rs; branches of Cu below the triangle in hind wing separated for a considerable distance by three rows of cells; branches of media leaving arculus distinctly above middle.
Neuræschna costalis [Williamson photo.].

Triangles with not more than 7 cells; M_2 more gently and regularly arched above fork of Rs; branches of Cu below the triangle in hind wings separated by one or (*Amphiæschna*) two rows of cells..... 2

1. Stigma very short, bounding about 2 cells below; triangle of three cells, the basal one not divided; branches of media leaving arculus well below its middle.
Caliæschna microstigma [Williamson photo.].

Stigma longer, bounding at least three cells below; triangle of at least five cells, two basal, at least in hind wing..... 2

2. Branches of media leaving arculus below the middle; only one row of cells between the Rs and supplementary vein below it; arculus close to base of triangle; stigma more or less swollen, bounding 5–5½ cells below; a dark patch at nodus.
Telephlebia godefroyi [Williamson photo.].

Branches of media leaving arculus above the middle; many rows of cells (about six at widest part) between Rs and supplementary vein below it; arculus not so close to base of triangle; stigma bounding 3–3½ cells below..... 3

3. Branches of Cu below triangle in hind wing separated by only one row of cells.
Amphiæschna from Siam [Williamson photo.].

Branches of Cu below triangle in hind wing separated by two rows of cells for a considerable distance.....*Amphiæschna ampla* [Williamson photo.].

The Jurassic *Cymatophlebia* and *Morbæschna* (see Bull. Amer. Mus. Nat. Hist., vol. 23, pp. 133–134, 141, 142) are certainly to be excluded from the Aeshninæ.

On other grounds, E. M. Walker divides the Aeshninæ into five groups. One of these corresponds with the Anacini above. The others may represent a number of tribes as follows:

Walker's divisions.	Radial sector not forked.		Radial sector forked.	
	Basal space with cross veins.	Basal space without cross veins.	Basal space with cross veins.	Basal space without cross veins.
BRACHYTRON GROUP.	BOYERIINI.	ALLOPETALIINI.		
Boyeria series.	*Boyeria.*	*Allopetalia.*		
		Gomphæschna.		
Brachytron series.			TELEPHLEBIINI.	BRACHYTRONINI.
			Telephlebia.	*Nasiæschna.*
			Caliæschna.	*Epiæschna.*
				Brachytron.
				Aeschnophlebia.
AESHNA GROUP.		BASIÆSCHNINI.	AMPHIÆSCHNINI.	AESHNINI.
		Basiæschna.	*Amphiæschna.*	*Aeshna.*
Aeschna series.		*Oplonæschna.*		*Coryphæshna.*
Gynacantha series.			NEURÆSCHNINI.	GYNACANTHINI.
			Neuræschna.	*Gynacantha.*
				Staurophlebia.

This agrees well enough with Walker's phylogenetic tree, except that *Neuræschna* can not apparently be derived from *Gynacantha*, nor *Amphiæschna* from *Aeshna*.

Order DIPTERA.

Family PHORIDÆ.

PARASPINIPHORA LAMINARUM (Brues).

Phora laminarum BRUES, Bull. Amer. Mus. Nat. Hist., vol. 24, 1908, p. 275.

This was described from a single imperfect specimen. Three others have been found at Florissant, all at station 17, two by Mrs. Cockerell, one by Mr. S. A. Rohwer. From these I have prepared the accompanying figures, which explain themselves. *a* is from one specimen; *b*, *c*, *d*, from another; *e*, from the third. All show the characteristic armature of the hind tibiæ, resembling that of the recent species *P. multiseriata* (Aldrich). The modern representative, however, has only two scutellar bristles instead of four.

FIG. 3.—PARASPINIPHRA LAMINARUM. *a*, DIAGRAMMATIC FIGURE OF MIDDLE TIBIA; *b*, PART OF MIDDLE TARSUS, SHOWING ARMATURE; *c*, PART OF HIND TARSUS, SHOWING ARMATURE; *d*, SCUTELLUM AND ADJACENT PARTS, SHOWING BRISTLES; *e*, END OF FEMALE ABDOMEN.

The new material of *P. laminarum* shows that the species has well-developed wings.

Plesiotype.—Cat. No. 59923, U.S.N.M.